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(54) **Method of making a ceramic arc tube for metal halide lamps**

(57) A method of making a ceramic arc tube for a metal halide lamp comprises the steps of forming as an integral unit a hollow body having one open end and a substantially closed end. The substantially closed end includes an outwardly extending capillary tube having an electrode receiving aperture therein that communicates with the hollow body. An end cap is then formed for closing the open end. The end cap comprises an annular portion and an extending capillary tube. The end cap is fitted into the open end of the hollow body to form a pre-assembly. The pre-assembly is then fired to seal the end cap to the hollow body to form an assembly and the assembly is subsequently fired to sinter the same.

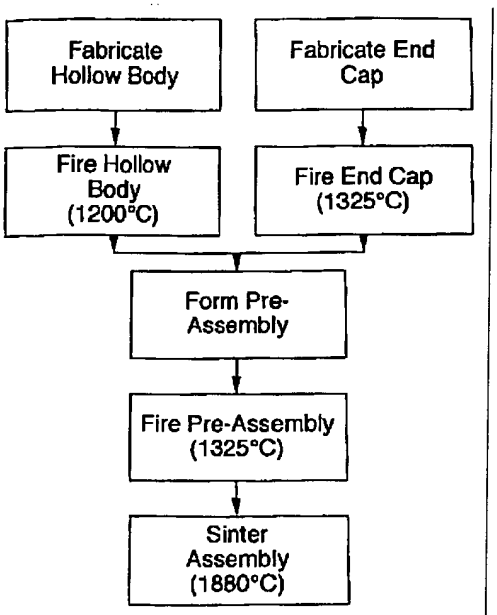

Fig. 4

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Description

TECHNICAL FIELD

This invention relates to a method of making ceramic arc tubes and more particularly to a method of making such arc tubes for use as metal halide lamps.

BACKGROUND ART

Ceramic arc tubes of materials such as polycrystalline alumina with one or more additives to control grain size have been used as the discharge vessel or arc tube for high-pressure sodium lamps. Recently, such arc tubes have been employed with metal halide lamps. See, for example, U.S. Patent No. 5,424,609. Such arc tubes have comprised 5 piece structures including a cylindrical body, a pair of end closures or buttons, and a pair of electrode receiving rods or capillary tubes sealed to the buttons. Manufacture of such arc tubes required extrusion or pressing of the individual components, as well as multiple assembly and heat treatment steps that increased handling and, therefore, cost.

Additionally, three piece structures have been proposed. In U.S. Patent No. 4,766,347 there is shown an arc tube having only a ceramic body with electrode receiving rods sealed directly therein. U.S. Patent No. 5,426,343 discloses a three-piece structure wherein a sealing button has an extending electrode rod receiving member integral therewith.

All of these approaches require extra heating and handling steps.

DISCLOSURE OF INVENTION

It is, therefore, an object of this invention to obviate the disadvantages of the prior art.

It is another object of the invention to enhance the production of arc tubes.

These objects we accomplished, in one aspect of the invention, by a method of making a ceramic arc tube for a metal halide lamp which comprises the steps of forming as an integral unit a hollow body having one open end and a substantially closed end. The substantially closed end includes an outwardly extending capillary tube having an electrode-receiving aperture therein that communicates with the hollow body. An end cap is then formed for closing the open end. The end cap comprises an annular portion and an extending capillary tube. The end cap annular portion has a diameter slightly larger than the diameter of the open and is fitted into the open end of the hollow body before firing, utilizing the elastic properties of the organic binders still contained in the components to allow the end portion to fit into the smaller open end. This structure forms a pre-assembly. The pre-assembly is then fired to remove the organic binders and to seal the end cap to the hollow body to form an assembly and the assembly is subsequently fired to sinter the same. Firing is generally continued until the body reaches a state of high translucency.

In this aspect of the invention, if the end cap and body are sintered without being joined together, the outside diameter of the annular portion of the end cap will be greater than the inside diameter of the open end of the hollow body.

In another aspect of the invention, these objects are accomplished by a method of making a ceramic arc tube for a metal halide lamp which comprises the steps of injection molding as an integral unit a hollow body having an open end and a substantially closed end. The substantially closed end has an outwardly extending capillary tube having an electrode receiving aperture therein which communicates with the interior of the hollow body. An end cap is injection molded for closing the open end. The end cap includes an annular portion and an extending capillary tube. The annular portion has the same diameter as the inside diameter of the open end of the hollow body. The end cap is fitted into the open end of the hollow body before firing and joined at a temperature above the softening point of the thermoplastic injection molding binder, with some pressure applied to bond the open end to the end cap. The assembly is then fired to remove organic binders and subsequently fired to sinter the same to a highly translucent state.

This use of these procedures reduces the handling and, thus, the cost of making ceramic arc tubes.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an elevational sectional view of a first element of the arc tube of the invention;

Fig. 2 is an elevational sectional view of a second element of the arc tube of the invention;

Fig. 3 is an elevational, sectional view of an assembled arc tube; and

Fig. 4 is a flow diagram of the steps of one embodiment of the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following disclosure and appended claims taken in conjunction with the above-described drawings.

Referring now to the drawings with greater particularity, there is shown in Fig. 1 an arc tube body 10 comprised of a first element 12 having a hollow body 14 with an open end 16 and a substantially closed end 18. The end 18 includes an outwardly extending capillary tube 20 having an aperture 22 therethrough. The transition from substantially closed end 18 to the capillary tube 20 includes a radius or chamfer 32.

An end cap 24 (see Fig 2) comprises an annular portion 26 and an outwardly extending capillary tube 28 with an aperture 30 therethrough. The end cap also has a radius or chamfer 34 joining the annular portion 26 to the capillary 28.

The hollow body 14 and end cap 24 are preferably formed from polycrystalline alumina containing minor amounts of magnesia and, in some instances, yttria and zirconia Such a material is shown in U.S. Patent No. 5,682,082. Other minor constituents can also be included, as is known in the art. In a preferred embodiment of the invention body 14 and end cap 24 are made by injection molding or gel casting and utilize Baikowski grade CR-6 alumina powder containing 0.05 weight percent magnesia.

After initial fabrication, the hollow body 14 is heated to remove binder material and impart handling strength. Such heating is at 1200°C for 120 minutes in an air atmosphere. The end cap 24 also is heated to remove binder material and cause the annular portion to shrink so that it will fit into open end 16. Such heating is at 1325°C for 120 minutes.

After this, the end cap 24 is inserted into open end 16 to form a pre-assembly that is then fired at 1325°C for 120 minutes in an air atmosphere to form the completed assembly. This firing shrinks the open end 16 and seals the unit together.

The assembly can be fired either horizontally or vertically for the final sintering operation, which occurs at temperatures above 1800°C in a hydrogen-containing atmosphere. Preferably, the firing temperature is 1880°C for 180 minutes and the atmosphere contains 100 % hydrogen.

In a preferred embodiment, for example, for a 35 watt lamp, the sintered arc tube would have an overall length of 34.7 mm; the "open" end 36 (Fig. 3) an outside diameter of 6.8 mm; the closed end 38 (Fig. 3) an outside diameter of 6.42 mm; a wall thickness for body 14 of 0.8 mm; a capillary tube outside diameter of 2.10 mm and an aperture diameter of 0.65 mm. The thickness of the annular portion 26 of end cap 24, and the wall thickness of the closed end 18, is 1.95 mm. The radii (or chamfers) 32 and 34 are between 0.2 and 1.0 mm and are preferably 0.5 mm.

While there have been shown and described what are at present considered the preferred embodiments of the invention, it will be apparent to those skilled in the art that various changes and modifications can be made herein without departing from the scope of the invention as defined by the appended claims.

Claims

1. A method of making a ceramic arc tube for a metal halide lamp comprising the steps of: forming as an integral unit a hollow body having one open end and a substantially closed end, said substantially closed end including an outwardly extending capillary tube; forming an end cap for internal engagement with said open end, said end cap including an outwardly extending integral capillary tube; fitting said end cap into said open end to form a pre-assembly; firing said pre-assembly to seal said end cap to said hollow body to form an assembly; and firing said assembly to sinter the same to a highly translucent state..

2. The method of Claim 1 wherein said hollow body has a first inside diameter and said end cap has a first outside diameter larger than said first inside diameter.

3. The method of Claim 2 wherein the fitting of said end cap into said open end to form a pre-assembly is accomplished by firing said end cap for a time and at a temperature sufficient to shrink said outside diameter of said end cap to equal or be smaller than said first inside diameter of said hollow portion.

4. The method of Claim 2 wherein the fitting of said end cap into said open end to form a pre-assembly is accomplished by fitting said end cap into said open end of said hollow body before firing by utilizing the elastic properties of the organic binders still contained in the components to allow the end of said end cap to fit into the slightly smaller inside diameter of said hollow body.

5. The method of Claim 1 wherein said hollow body has a first inside diameter and said end cap has a first outside diameter the same as or slightly smaller than said first inside diameter.

6. The method of Claim 5 wherein the fitting of said end cap into said open end to form a pre-assembly is accomplished by fitting said end cap into said open end of said hollow body before firing, and joining said end cap to said open end of said hollow body at a temperature above the softening point of the thermoplastic organic binder while applying pressure to the outside diameter of said hollow body.

7. The method of Claim 2 wherein said hollow body is cylindrical and said open end has a diameter greater than the diameter of said closed end after assembly and sintering.

8. The method of Claim 2 wherein said first outside diameter of said end cap is from about 3 to about 6% greater than said first inside diameter of said hollow body.

9. The method of Claim 5 wherein said hollow body is cylindrical and said open end had a diameter approximately equal to the diameter of said closed end after assembly and sintering.

10. The method of Claim 5 wherein said first outside diameter of said end cap is from about 0 to 0.1 mm smaller that said first inside diameter of said hollow body.

11. The method of Claim 1 wherein said outwardly extending integral capillary tubes are blended into said hollow body with a fillet radius of 0.2 to 1.0 mm.

12. The method of Claim 1 wherein said outwardly extending integral capillary tubes are blended into said end cap and said hollow body with a chamfer of 0.2 to 1.0 mm.

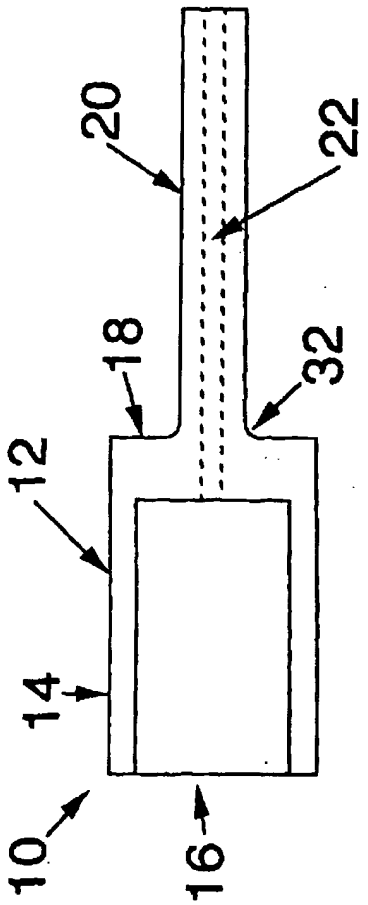

Fig. 1

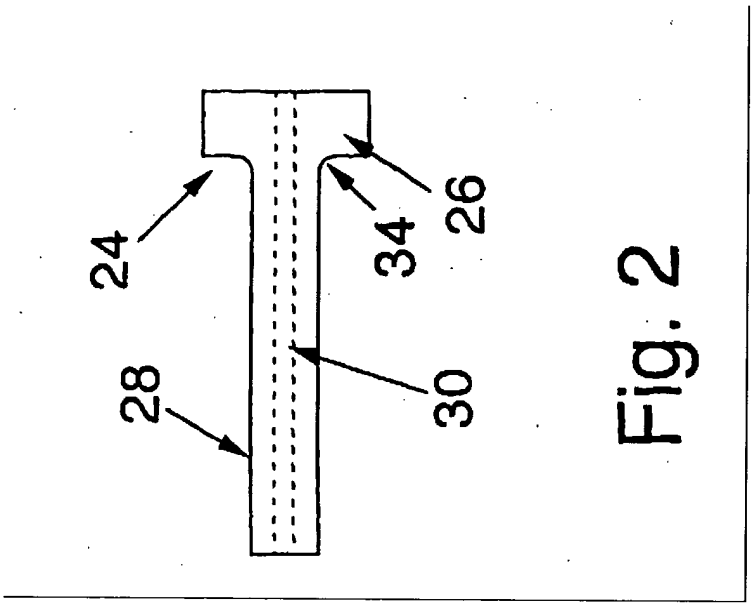

Fig. 2

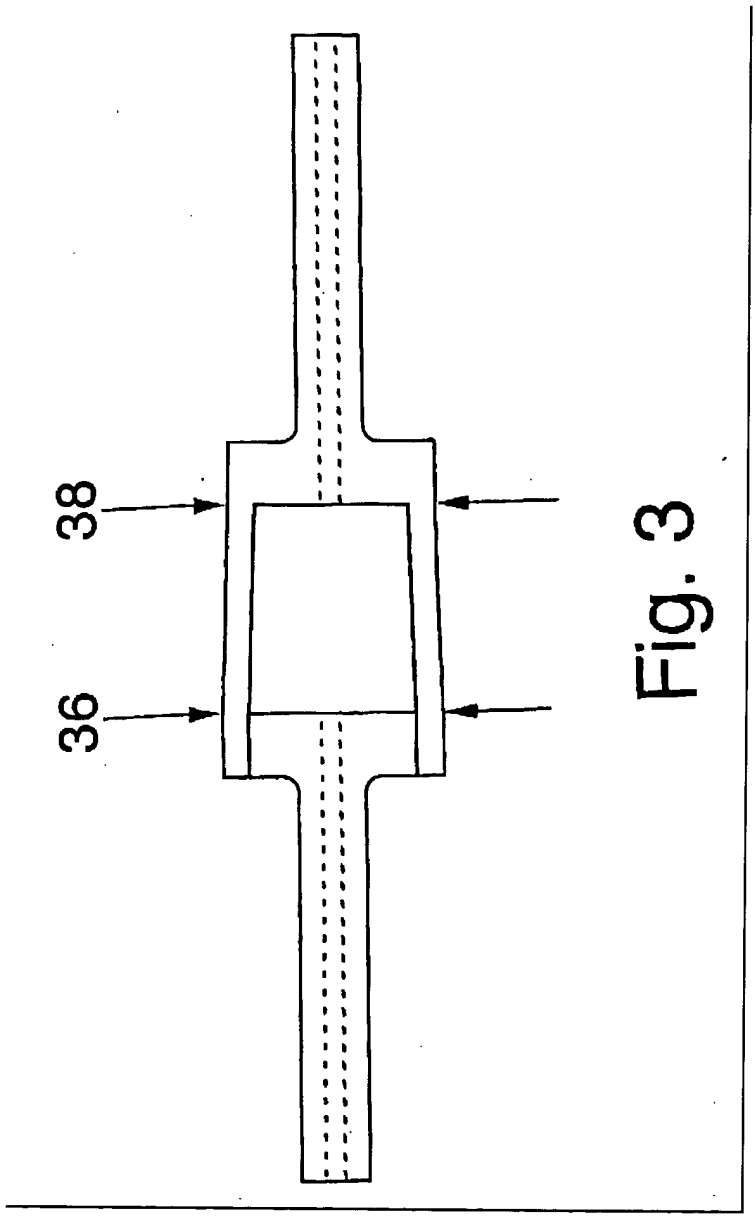

Fig. 3

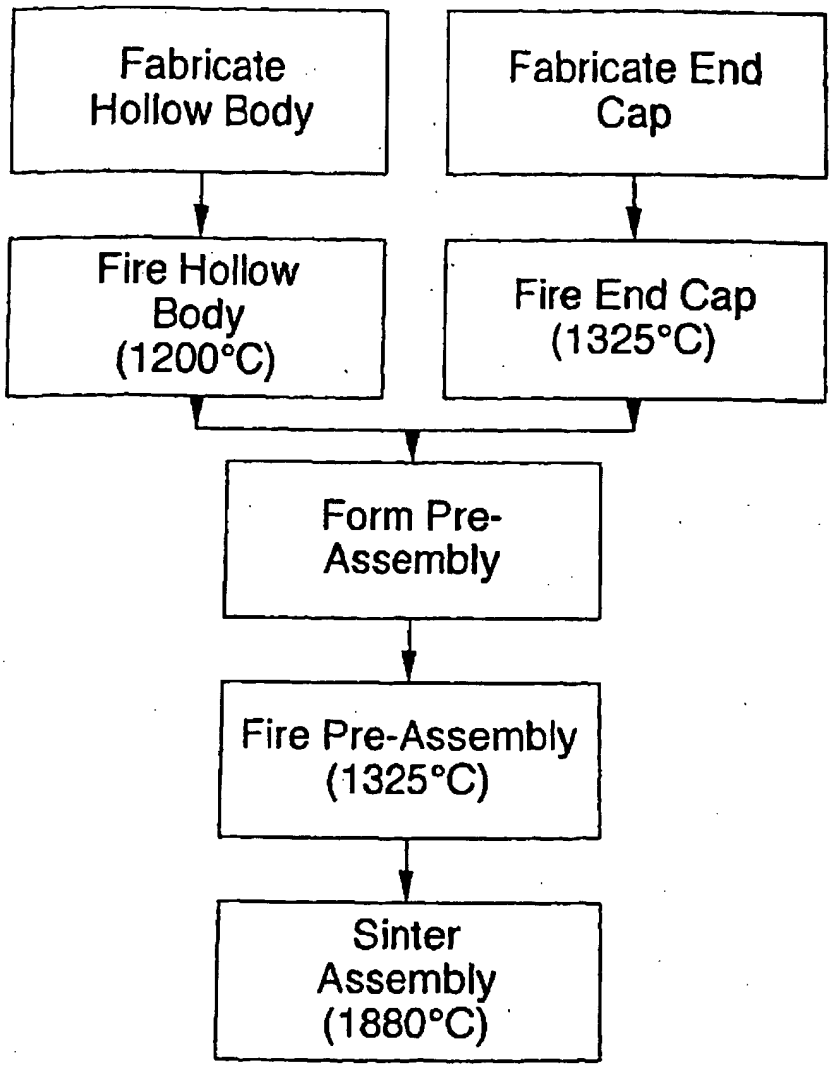
Fabricate Hollow Body
Fabricate End Cap
Fire Hollow Body (1200°C)
Fire End Cap (1325°C)
Form Pre-Assembly
Fire Pre-Assembly (1325°C)
Sinter Assembly (1880°C)

Fig. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 12 3779

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 0 827 177 A (NGK INSULATORS LTD) 4 March 1998 (1998-03-04) * column 11, line 55 - column 12, line 8 * * column 10, line 10 - line 24; claims 1,4,7,8; figures 6,7,8C *	1-3,7, 11,12	H01J9/24 H01J61/82 H01J61/30
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A	EP 0 331 154 A (FELDMUEHLE AG) 6 September 1989 (1989-09-06) * column 4, line 34 - column 5, line 32 * * column 6, line 19 - line 31; figures 1,2,7,17 *	1,5,11, 12	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 April 2000	Deroubaix, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 99 12 3779

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82